Modeling of the Ultrasonic/Sonic Driller/Corer: USDC

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Abstract – Future NASA missions to Mars require sampling techniques for in-situ analysis and/or sample return to Earth. One of the major limitations of sample collection on Mars and other low gravity environments using conventional drilling is the need for high axial force during drilling. In order to address this problem an ultrasonic/sonic drilling/coring (USDC) mechanism based on an ultrasonic horn driven by a piezoelectric stack has been developed. The horn drives a free mass, which resonates, between the horn and drill stem. Tests have shown that this device addresses some of the key challenges to this NASA objective of planetary in-situ analysis or sampling. The USDC is lightweight (450 g), requires low preload (< 5N) and can be driven at low power (5W). The device has been shown to drill various rocks including granite, diorite, basalt and limestone. Although the drill is driven electrically at 20 kHz a substantial sub-harmonic acoustic component is found that is crucial to drilling performance. Models that explain this low frequency coupling in the horn, free mass, drill stem and rock will be presented.